enes
EUROPEAN NETWORK
FOR EARTH SYSTEM MODELLING

http://enes.org/

Copernicus and H2020 Programme by the ENES Data Task Force.

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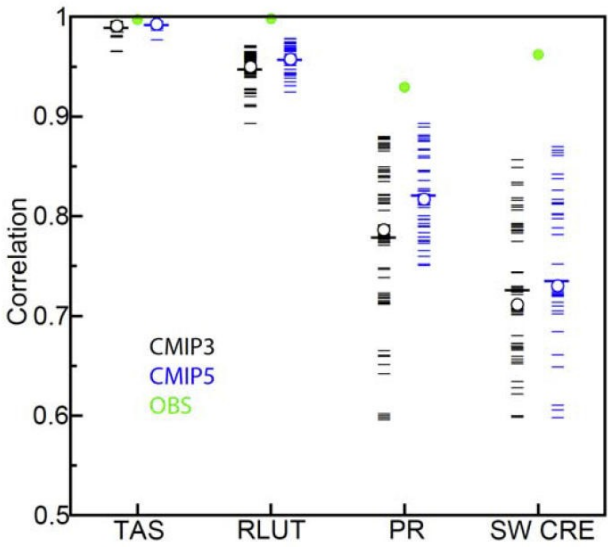
Horizon 2020 (H2020)

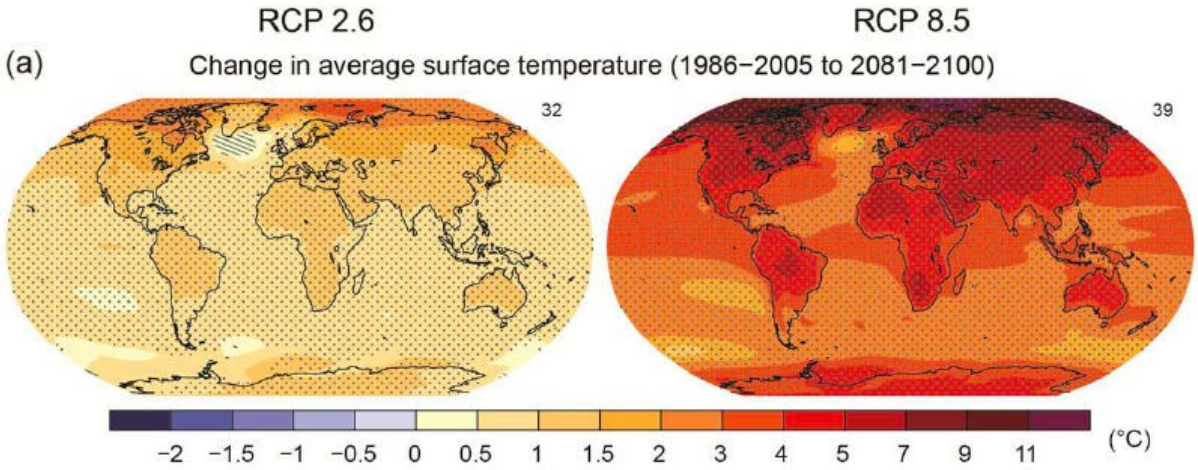
- H2020 is the biggest EU research and innovation programme ever. Almost 80 billion € of funding is available over seven years (2014 to 2020) – in addition to the private and national public investment that this money will attract.
- Within H2020 three types of activity are supported:
  - The first activities are targeted to the **development of new world-class research infrastructures.** Support will be provided for the implementation and operation of the research infrastructures listed on the ESFRI Roadmap.
  - The second set of activities aims at **optimising the use of the national facilities by integrating them** into networks and opening their doors to all European researchers. This is a continuity of the so-called Integrating Activities under FP7.
  - The third action will support **further deployment and development of ICT based e-infrastructures** which are essential to enable access to distant resources, remote collaboration, and massive data processing in all scientific fields.

CMIP international coordinated experiments

Evaluate | **Understand** | **Predict**

Pattern correlation with observations





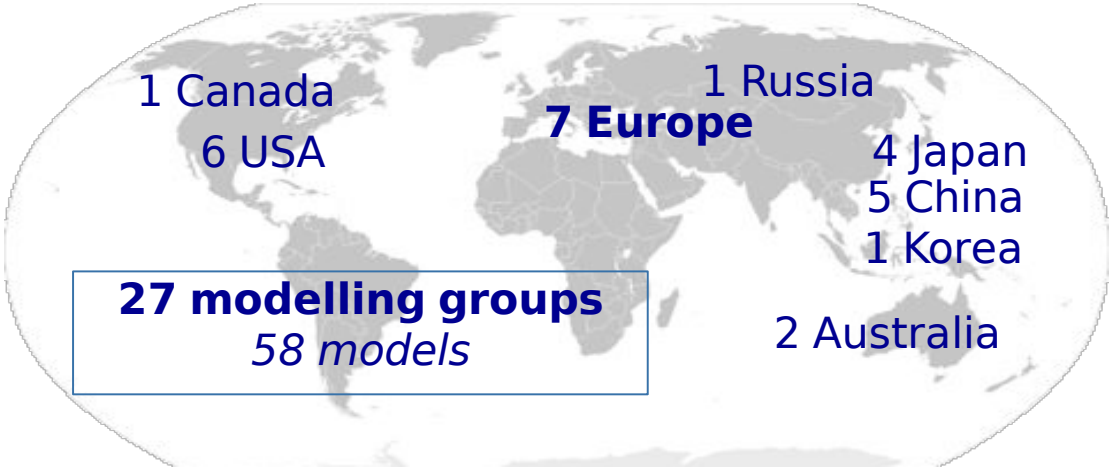
IPCC AR5 (2013)

CMIP5

3400 simul. yrs up to > 12000 yrs

50 expts up to > 160 expts

2000 Tbytes (CMIP3: 36)



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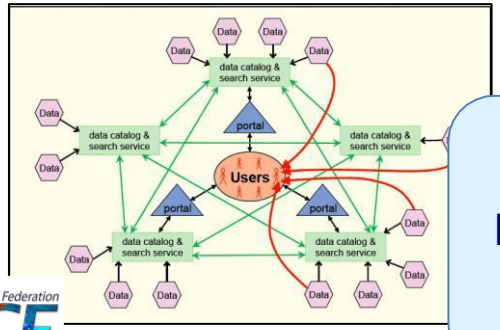
IS-ENES (2009-2017) : Infrastructure for ENES

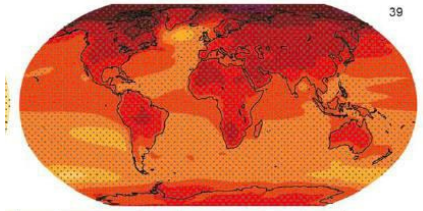
is-enes
INFRASTRUCTURE FOR THE EUROPEAN NETWORK FOR EARTH SYSTEM MODELLING
http://is.enes.org/

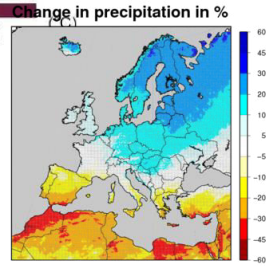
Climate models
Environment software tools
ESM ca 1000 man years

High-performance computers
& storage facilities



Data & Metadata
Distributed Database ESGF
Open Access





Earth System Grid Federation ESGF

Climate research & Impact research
Climate services

Support WCRP international experiments
Used in IPCC Assessments Reports

WCRP
World Climate Research Programme

IS-ENES 2 activities

Foster the integration of the European ESM community

Foster interactions, synergies and common strategies

ENES Infrastructure Strategy :

- Infrastructure for model evaluation → Need for routine evaluation
- Mid-term update 2017 → 5 + 2 new recommendations
- Long-term sustained European RI → Still to be done

Strengthen governance:

- ENES Scientific Officer → Important support
- ENES Organisation → Key role of HPC and Data task force
- Governance on common software → Clarified levels
- *International governance ESGF, WIP* → *Support from IS-ENES*

Community building :

- 2 Training schools on ESM → *Worked well – but lot of work*
- *ENES portal* → *Important common basis*

IS-ENES 2 activities

Facilitate the dissemination of ESM simulation results

Ease use of model results for climate research & for climate impact research

Service around model results :

- CMIP5 & CORDEX on ESGF → Essential role
- Service to providers (data nodes & users) → Essential role (eg. Help)

Metadata

- Upgrades & Interoperability, CMIP6 → Leading role, simplified

Develop more efficient tools for ESGF:

- Core services → Europe : half WGs
- Security issues & CMIP6 → Watch out
- Quality control, monitoring, synchro → leading role

Services for climate impacts - Climate4impact :

- Tools, downscaling, indices → *Now a basis for other projects*

Societal innovation:

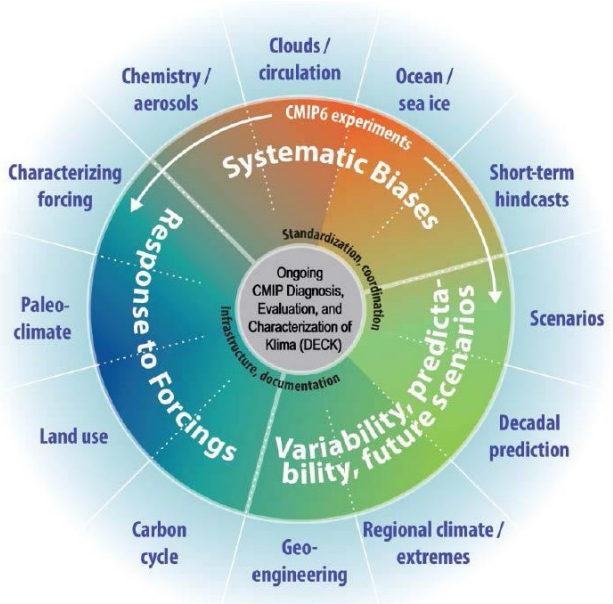
- To corporate (KIC) → *Mater classes but limited*
- *To climate services centres* → *link with Copernicus*

Support CMIP6

European models in CMIP6

Country	name of model (CMIP5)
Consortium	EC-EARTH
France	IPSLCM5
France	CNRM-Cerfacs
Germany	MPI-ESM
Italy	C-ESM
UK	HadGEM2
Norway	NorESM

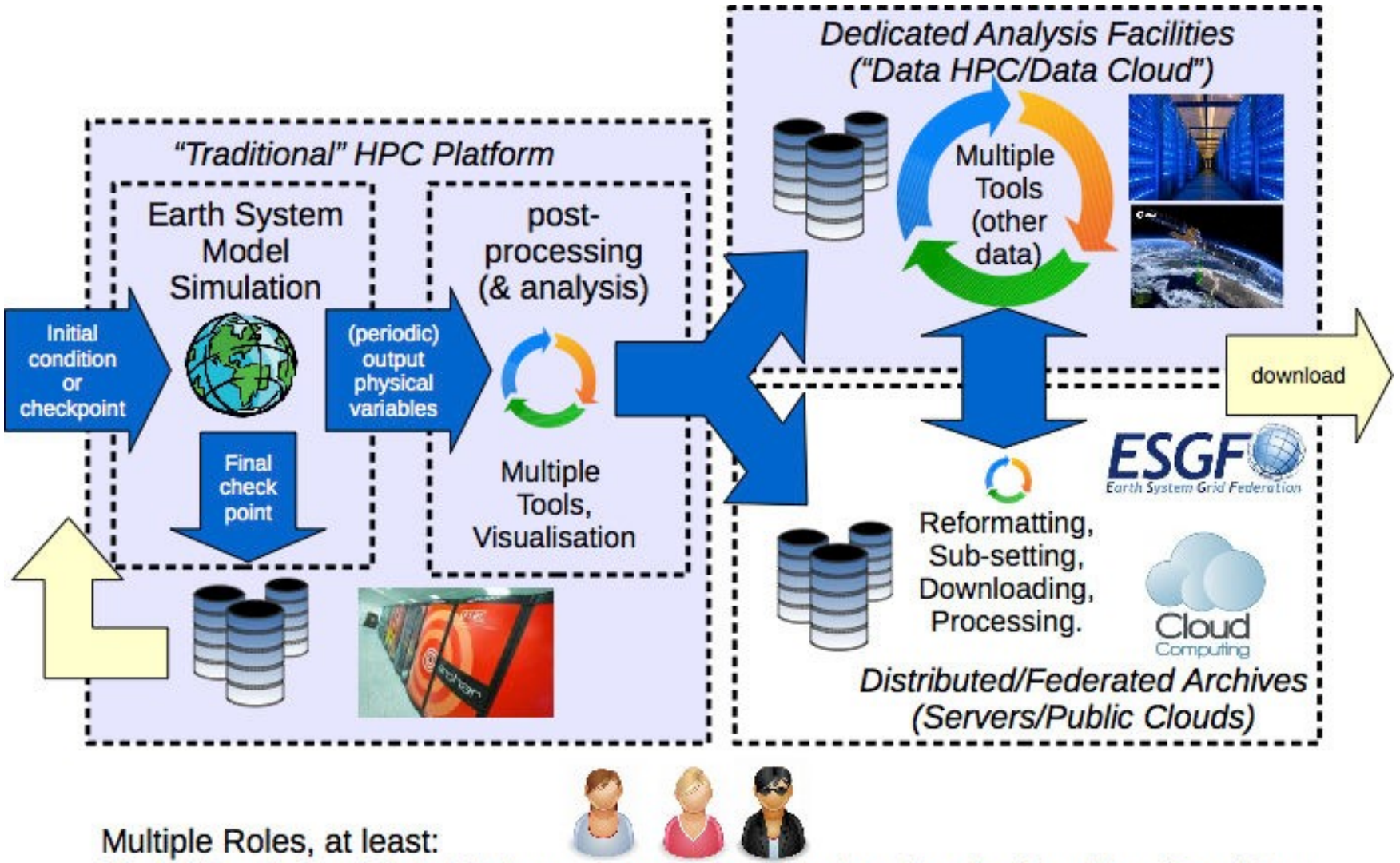
Germany:
AWI-CM
EMAC



Short name of MIP	AWI-CM	CMCC	CNRM	EC-Earth	EMAC	IPSL	MPI-ESM	Nor ESM	UK ESM	Had GEM3
AerChem MIP	0	0	1	1	1	1	0	1	1	0
C4MIP	0	1	1	2	0	1	1	1	1	0
CFMIP	0	0	1	1	0	1	1	1	0	1
DAMIP	0	0	1	0	0	1	0	1	0	1
DCPP	0	1	1	1	0	1	1	1	0	1
FAFMIP	0	0	1	0	0	1	1	0	0	1
GeoMIP	0	0	1	1	0	1	1	2	1	0
GMMIP	0	1	1	0	0	1	1	0	0	1
HighRes MIP	1	1	1	1	0	2	1	2	0	1
ISMIP6	0	0	1	1	0	1	1	0	1	0
LS3MIP	0	1	1	1	0	1	1	2	1	0
LUMIP	0	1	1	1	0	1	1	1	1	0
OMIP	1	1	1	0	0	1	1	1	1	0
PMIP	1	0	1	1	0	1	1	1	1	0
RFMIP	0	0	1	0	0	1	1	1	0	1
Scenario MIP	0†	1	1	1	0	1	1	1	1	0
VolMIP	0	0	0	1	0	1	1	1	1	0
CORDEX	1	0	1	1	0	1	0	0	1	0
DynVar	0	0	0	1	0	1	1	0	0	1
SIMIP	1	1	1	1	0	1	1	1	1	0
VIACS AB	0	1	0	1	0	0	0	1	1	1

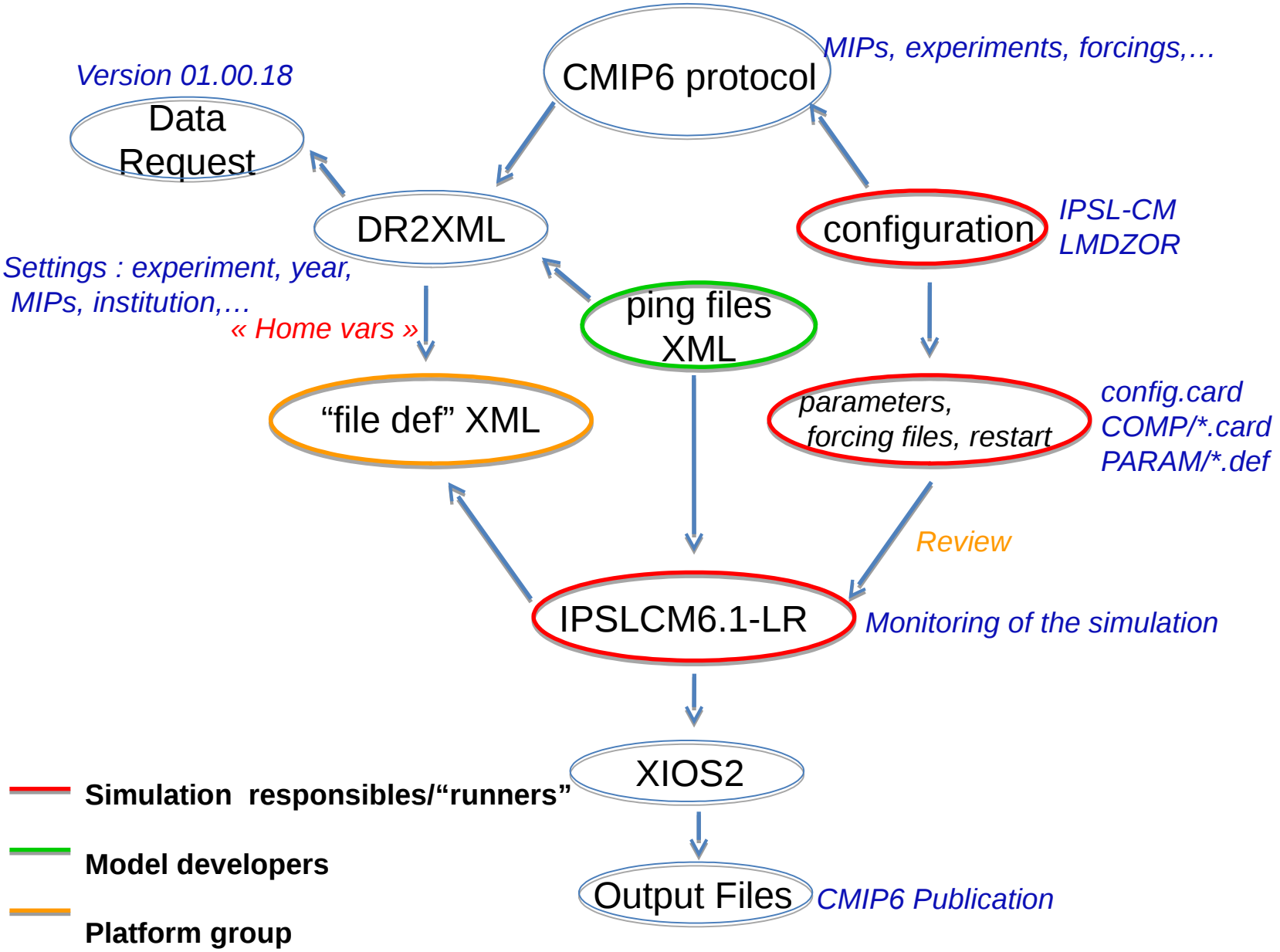
Source Veronika Eyring

Multiple type of storage & data interaction



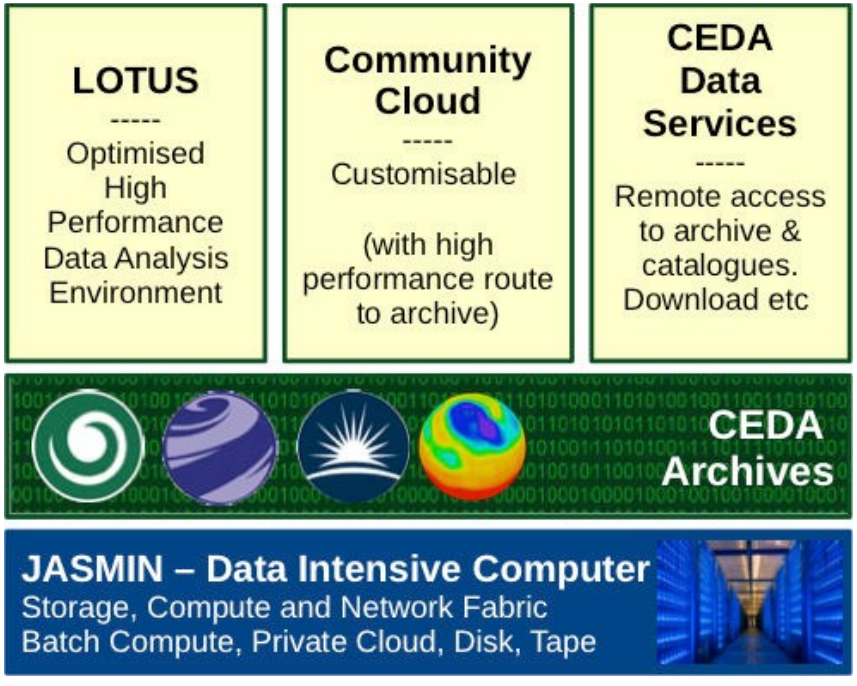
Multiple Roles, at least:
Model Developer, Model Tinkerer, Expert Data Analyst, Service Provider, Data User

Management of output



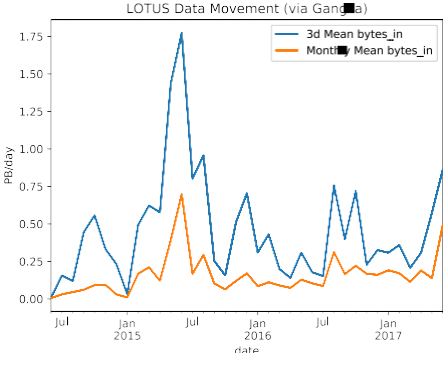
Dedicated Analysis Facilities

Example : JASMIN – (IPSL and DKRZ operates as well).

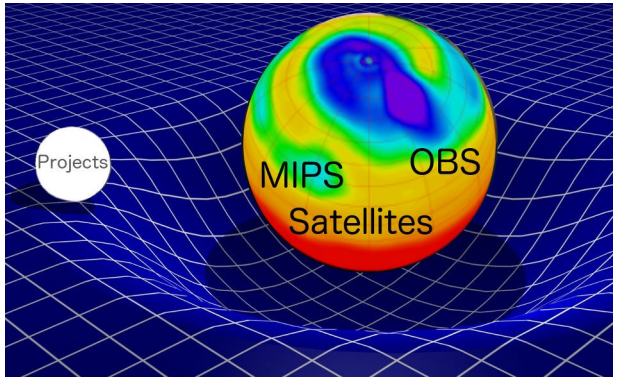


- 5 PB of CURATED POSIX archive data (and growing, with 10 PB expected in next 2 years).
- 6 PB of USER POSIX data on disk (and growing)
- Lots of EPHEMERAL POSIX data (need space for analysis!)

Moving PB per day in and out of LOTUS (the batch cluster):



The importance of data gravity; when you have data, more data comes to you!



Storage issues and action arising

Issues:

- ***Cost:*** Disk prices not falling as fast as they used to.
- ***Behaviour:*** Larger groups sharing data for longer, which means ***data is "hot" for longer.***
- ***Performance:*** Traditional (POSIX) disk not performant at scale.
- ***Software****: Little sokware for our domain which can exploit "OBJECT store" disk (hard to use the public cloud.)*
- ***Tape:*** Tape remains important, particularly for ***large amounts of "cold" data***.

Community Action: **ESIWACE "Exploitability"** work package:

1. Better understanding of costs and performance of existing and near-term storage technologies.
2. New "***Earth System Middleware***" prototype

   Provides an interface between the commonly used HDF library and storage which addresses both the performance of POSIX and the usability of object stores.

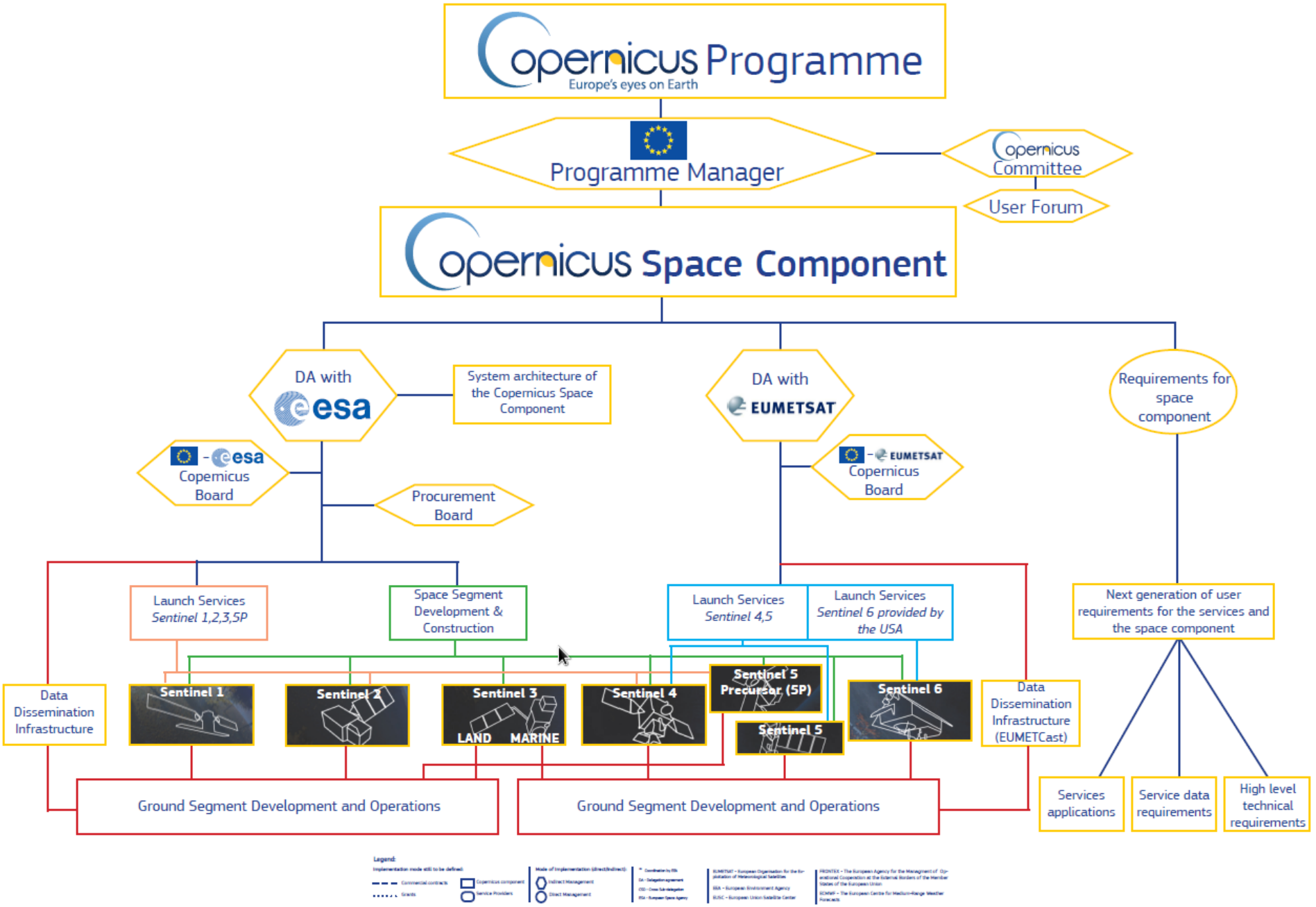
3 New "***Semantic Storage Library***" prototype:

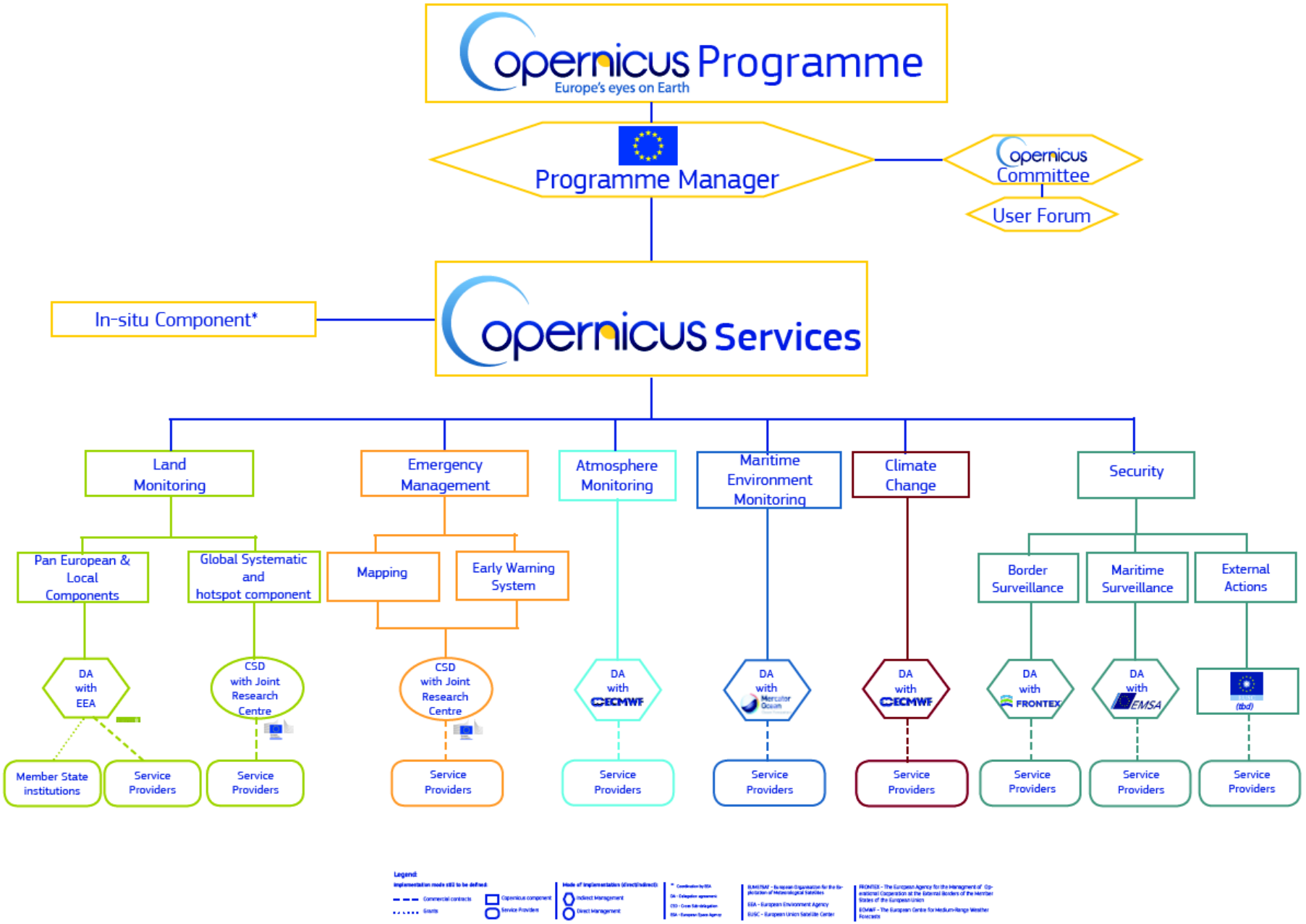
Python library that uses a "weather/climate" abstraction (CF--NetCDF data model) to allow one "file" to be stored across tiers of, e.g. POSIX disk, OBJECT store, and TAPE.

Cloud computing & Big Data

Three domains of interest to weather and climate community:

- New Fabric and infrastructure (private/public cloud)
  - Exploiting virtualisation to provide flexible and elastic services. Not suitable for large scale simulations, but big role to play in analysis facilities.
  - Large scale use will depend on addressing usability of object stores.
- New compute paradigms emerging (in our community)
  - New ways of arranging data and scheduling compute across hardware (e.g. HADOOP, SPARK) – *not used*
  - Some small scale experiments reported in the literature. DASK experiments underway at the UK Met Office (*http://www.informa6cslab.co.uk/*)
- New ways of exploiting algorithms emerging (in our community).
  - e.g. using machine learning to identifying patterns in data, something we've done for decades, but with new and (possibly) better tools.
  - Experiments comparing traditional methods to new methods are underway (e.g. at LLNL in the US) to evaluate potential.
  - Possible use for Quality Control of data (e.g. unusual field) or Parameterisations (e.g. optimal parameters)


Copernicus Programme
Europe's eyes on Earth
Programme Manager
Copernicus Committee
User Forum
Copernicus Space Component
DA with esa
System architecture of the Copernicus Space Component
DA with EUMETSAT
Requirements for space component
esa Copernicus Board
Procurement Board
EUMETSAT Copernicus Board
Launch Services Sentinel 1,2,3,5P
Space Segment Development & Construction
Launch Services Sentinel 4,5
Launch Services Sentinel 6 provided by the USA
Next generation of user requirements for the services and the space component
Data Dissemination Infrastructure
Sentinel 1
Sentinel 2
Sentinel 3
LAND
MARINE
Sentinel 4
Sentinel 5 Precursor (5P)
Sentinel 5
Sentinel 6
Data Dissemination Infrastructure (EUMETCast)
Ground Segment Development and Operations
Ground Segment Development and Operations
Services applications
Service data requirements
High level technical requirements


Copernicus Programme
Europe's eyes on Earth
Programme Manager
Copernicus Committee
User Forum
In-situ Component*
Copernicus Services
Land Monitoring
Emergency Management
Atmosphere Monitoring
Maritime Environment Monitoring
Climate Change
Security
Pan European & Local Components
Global Systematic and hotspot component
Mapping
Early Warning System
Border Surveillance
Maritime Surveillance
External Actions
DA with EEA
CSD with Joint Research Centre
CSD with Joint Research Centre
DA with ECMWF
DA with Mercator Ocean
DA with ECMWF
DA with FRONTEX
DA with EMSA
(tbd)
Member State institutions
Service Providers
Service Providers
Service Providers
Service Providers
Service Providers
Service Providers
Service Providers
Service Providers
Service Providers

Copernicus Climate Change Service (C3S)

Beta version http://climate.copernicus.eu

Climate Data Store

- ECVs past, present and future
- Observed, reanalysed and simulated
- Derived climate indicators

Sectoral Information System

Evaluation and Quality Control

- Monitors quality of C3S products and services
- Ensures C3S delivers state-of-the-art climate
- information to end-users

Outreach and Dissemination

- Web content
- Public outreach

What simulations will be available from the CDS?

- **Global projections** [from CMIP-5 Core and Tier-1 simulations]
  - Pre-industrial control with prescribed, non-evolving concentrations of atmospheric gases and aerosols;
  - Historical ensemble, 1850 to at least 2005, imposed changing concentrations and forcings, minimum of 3-member ensemble [Tier-1];
  - AMIP ensemble, 1979 to at least 2008, prescribed SST and sea-ice concentration, other forcings as in Historical ensemble above, minimum of 3-member ensemble [Tier-1];
  - Projections following RCP 4.5 and 8.5 concentration scenarios, years 2006-2100, **preferably from models with multi-member ensembles**
  - Optionally: Projection following RCP 2.6 and 6.0 emission scenario, years 2006-2100, **preferably from models with a 3-member ensemble**

- **Regional projections:**
  - Existing simulations from the Euro-CORDEX and Med-CORDEX projects
  - New CORDEX simulations for a pan-European domain based on an agreed “3-D matrix” of regional climate models, boundary conditions from global models, concentration scenarios (RCPs)

Climate projections contract

Global projection service (C3S 34a)

- **Lot 1: Support to one Earth System Grid Federation node in Europe** (**CP4CDS:** lead contractor: STFC (UK), start 1 Oct. 2016, end Dec. 2019)
  - Solution to access and manipulate global climate projection data from the CMIP archive, consistent with the requirements of climate services

- **Lot 2: Multi-model product generation** (**MAGIC**: lead contractor: KNMI, start 1 Oct. 2016, end Mar 2019)
  - **metrics for fidelity** of models in simulating historical climate, to be **translated into quality** for specific applications
  - **interactive tools** for generic products (e.g. maps of intra-ensemble variability for different models and scenarios), and **tailored products** for several economic sectors

- **Lot 3: Roadmap towards a reference set of climate projections for Europe** (**CRECP**; lead contractor: UKMO, start 1 Sep. 2016, end Nov. 2018)
  - Studies on how well climate projections address sectoral needs, to guide requirements for the operational phase of C3S. Areas of interest: the benefit of **ensemble size versus resolution** for global models, and the benefit of **initialised decadal predictions,** in relation to the specific needs of different economic sectors

Climate projections contract

Regional projection service (C3S 34b)

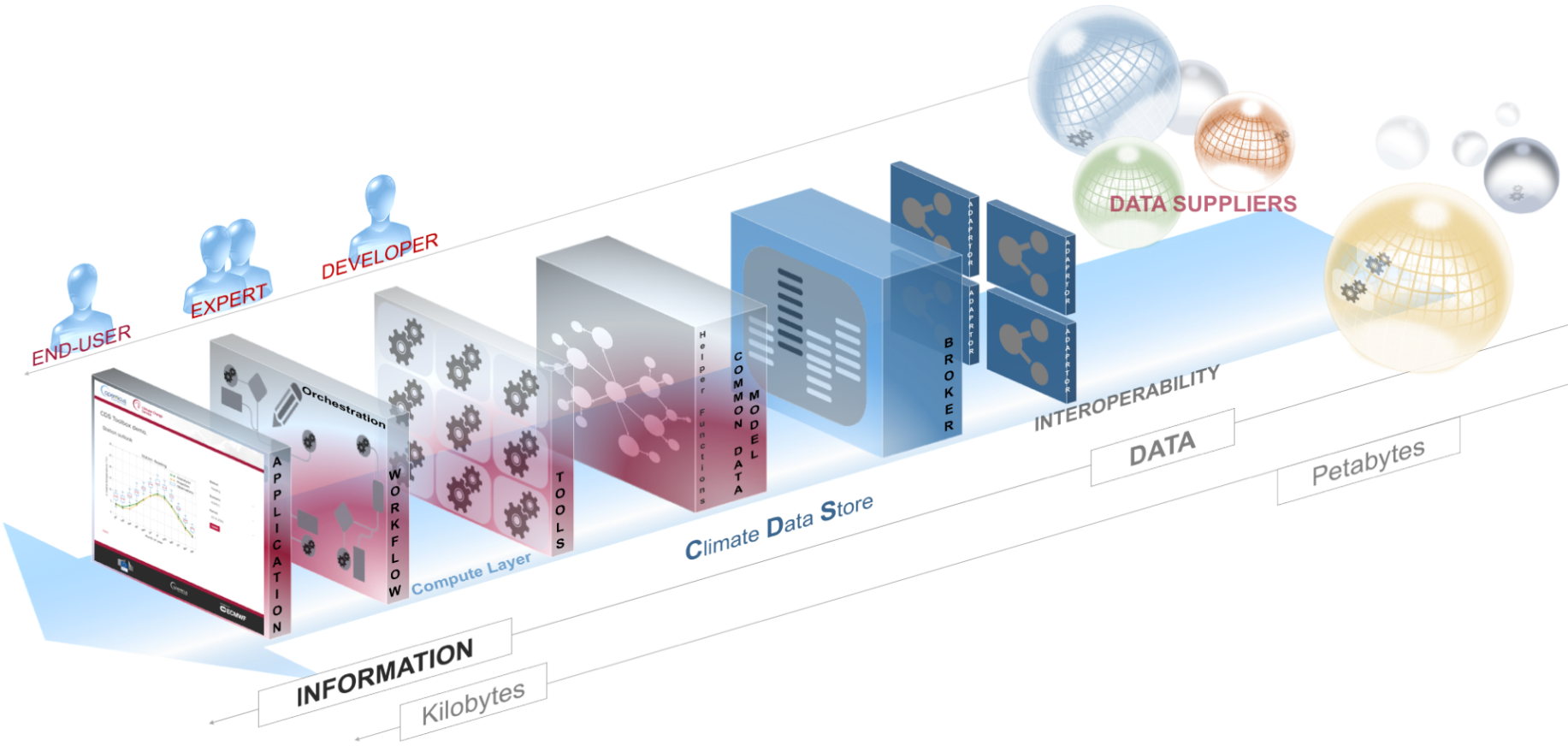
- **Lot 1: CORDEX for the Copernicus Data Store (CORDEX4CDS**; lead contractor: CNRS (France), start 1 May 2017, end Apr 2021**) :**
  - facilitate access and manipulation (via the CDS) of output of regional climate projections over Europe and boundary conditions from GCM simulations needed for future regional projections

- **Lot 2: Producing regional climate projections leading to European services (PRINCIPLES;** lead contractor: SMHI (Sweden), start 1 May 2017, end Apr 2021**)**
  - define and complete a matrix of global/regional model combinations and scenarios, which allows robust assessment of the uncertainties arising from these factors in a multi-model set of regional projections

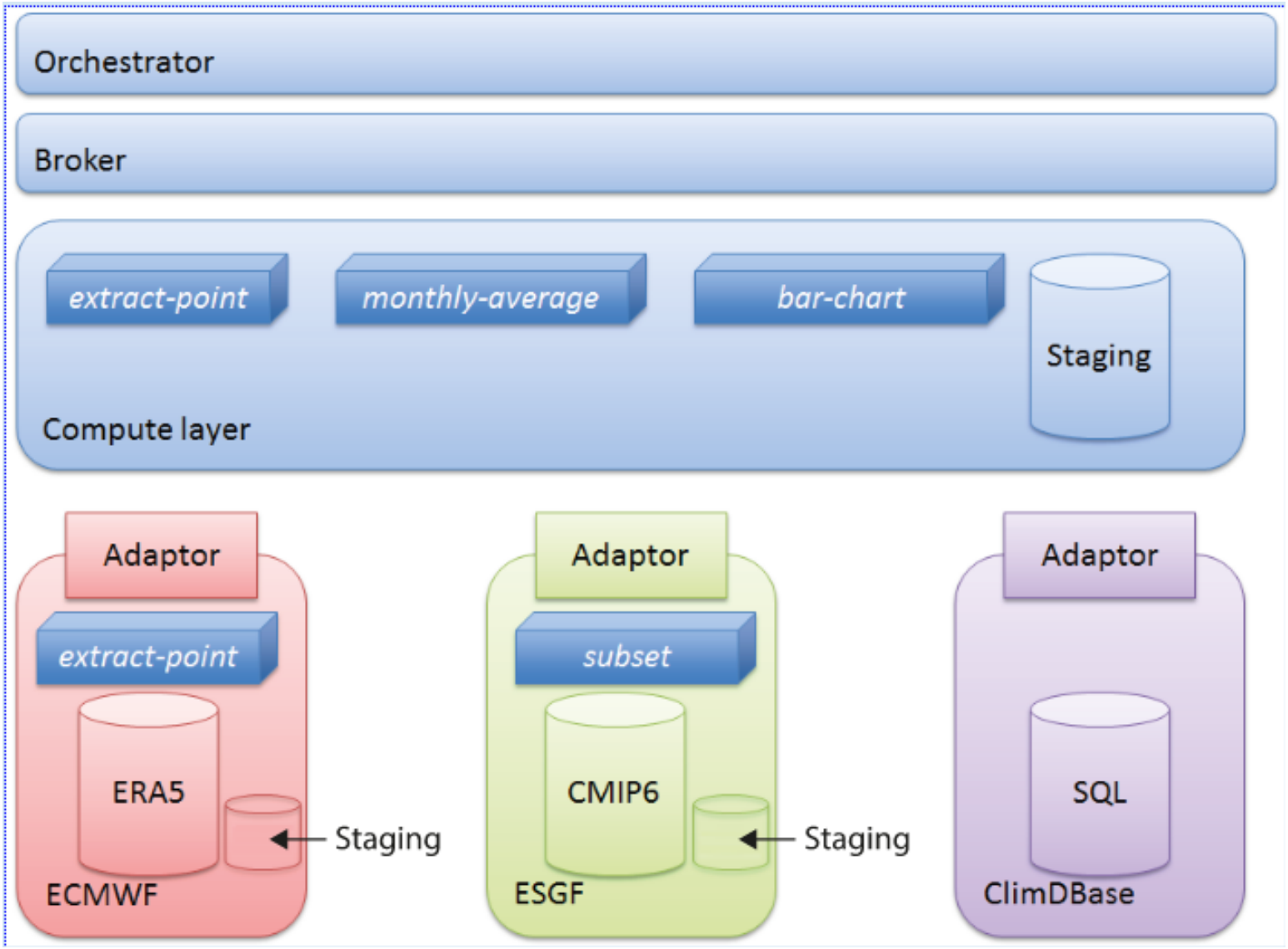
Evaluation and quality control for climate projection services

- **C3S 51 Lot 4: Data evaluation for climate models** (**DECM**: lead contractor: FMI, start 1 Aug. 2016, end Oct. 2018).
  - Conduct survey of user requirements, evaluate user feedback about services provided by 34a and 34b contracts, provide a gap analysis.

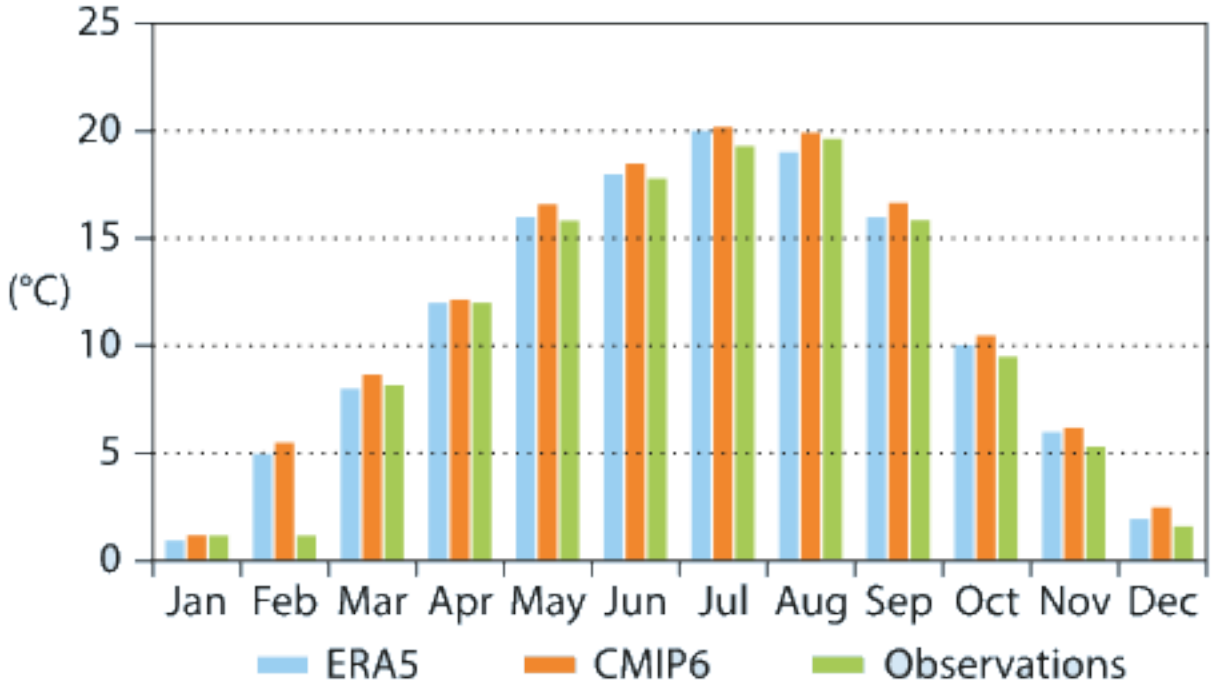
Who are they talking to ?



High Level Architecture



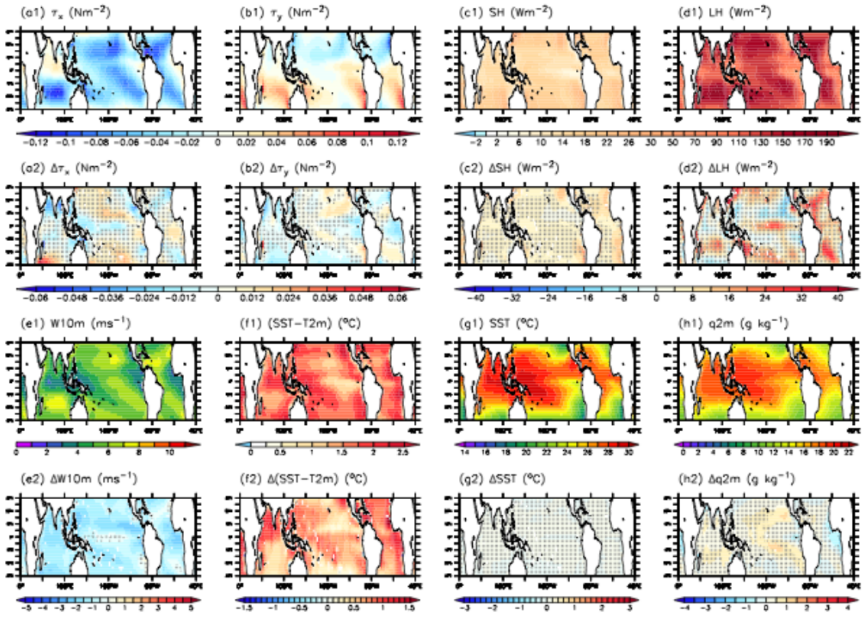
High Level Result



What do users gain from C3S?

- Improved reliability in the access to climate projection data through the Climate Data Store
- Products computed from models which show good fidelity in the simulation of climate during the recent decades (as quantified by appropriate metrics)
- Improved estimates of uncertainties allowed by focusing on models that provide ensemble simulations of individual scenarios
- User defined indices and products tailored to specific application sectors
- Quality and usability of products tested by an Evaluation and Quality Control consortium

Questions ?


(a1) τ_x (Nm^{-2})
(b1) τ_y (Nm^{-2})
(c1) SH (Wm^{-2})
(d1) LH (Wm^{-2})
(a2) $\Delta\tau_x$ (Nm^{-2})
(b2) $\Delta\tau_y$ (Nm^{-2})
(c2) ΔSH (Wm^{-2})
(d2) ΔLH (Wm^{-2})
(e1) W10m (ms^{-1})
(f1) (SST−T2m) (°C)
(g1) SST (°C)
(h1) q2m (g kg^{-1})
(e2) ΔW10m (ms^{-1})
(f2) Δ(SST−T2m) (°C)
(g2) ΔSST (°C)
(h2) Δq2m (g kg^{-1})